Italian leech-shaped glass fibula bow from the Hallstatt period, discovered in Poland

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The article presents the results of a laboratory analysis of the glass of a leech-shaped fibula bow discovered in a Hallstatt C grave in Gorszewice, Greater Poland. The fibula comes from Italy and is dated sometime to the end of the 8th or the 7th century BC. Both of the inner sides with a yellowish colour and the external side that appeared dark blue, nearly black, were examined. Like low magnesium and medium potassium glass of glassy faience present in the Hallstatt C period, the glass of the Gorszewice fibula bow is characterized by medium contents of K_2O, high Al_2O_3 and Fe_2O_3, and a relatively high level of B_2O_3, TiO_2 and BaO. The inner and outer glass of the Gorszewice fibula bow have an identical, or nearly the same chemical composition. Higher levels of several oxides occurred in the dark glass, indicating that they must have been introduced with the colourant. The yellowish glass was not coloured intentionally; its colour is the result of the presence of iron compounds in the sand.

glass – glassy faience – leech-shaped fibula bow – Hallstatt period – chemical analyses – LA-ICP-MS

Návlek lučíku spony italské provenience z doby halštatské v Polsku. *Článek představuje výsledky analýzy skleněného návleku lučíku spony, objeveného v hrobě datovaném do období Ha C v Gorszewicích, Velkopolsko. Spona pochází z Itálie zřejmě na sklonku 8. nebo v 7. století BC. Zkoumány byla jak vnitřní vrstva nažloutlé barvy, tak povrchová vrstva, na pohled tmavě modrá až černá. Stejně jako LMMK sklo skelné fajánse, běžné v období Ha C, i sklo návleku lučíku spony z Gorszewic charakterizuje střední koncentrace K_2O, vysoká koncentrace Al_2O_3 a Fe_2O_3, a poměrně vysoká úroveň B_2O_3, TiO_2 a BaO. Vnitřní i vnější skelná vrstva návleku lučíku spony z Gorszewic mají téměř stejné chemické složení. Vyšší koncentrace některých oxidů se projevují v tmavším skle, což je způsobeno příměsí barvících složek. Nažloutlé sklo nebylo obarveno záměrně: jeho barva je způsobena přítomností sloučenin železa v písku.*

sklo – skelná fajáns – návlek lučíku spony – doba halštatská – chemické analýzy – LA-ICP-MS

1. Introduction

The cemetery in Gorszewice (western Poland) is attributed to the Lusatian culture and is dated to Hallstatt C (about 750/700–600 BC) and the beginning of Hallstatt D (*Pieczyński 1953*; *Narożna-Szamałek – Szamałek 2007*). The graves excavated at the site featured a large number of objects imported from Italy and the eastern Alpine regions. A richly furnished grave (LV) from the Hallstatt C period yielded, among other items, a bronze fibula with a glass leech-shaped bow (*Fig. 1*).

Fibulae of this kind, *Glasbügelfibeln* in German (e.g. *Haevernick 1959*; *Koch 2010*; sometimes reffered to as brooch slider or brooch decoration in English), vary in terms of their shape, decoration and production technique. According to *L. C. Koch* (*2010*, 276), the Gorszewice fibula is a 1dA form in her classification, although by size it should actually be a 1cA form. Jewellery of this type was common in the Apennine Peninsula, mainly in the vicinity of Bologna and in Verucchio, around the end of the 8th and in the 7th century BC (*Koch 2011*, 103). The Gorszewice brooch is the only 1cA or 1dA fibula found outside Italy (*Fig. 2*). It must have come to Poland either from Bologna or from its close vicinity (*Koch 2010*, 194).

A few of the 200 known *Glasbügelfibeln* have had the chemical composition of the glass analyzed. *C. Braun* (*1983*, Tab. 20) examined a leech-shaped fibula bow of unknown provenance dated to Hallstatt D, and A.C. Towle examined four leech-shaped fibula bows from 800–600 BC, discovered in Italy (however, fully quantitative results were obtained for only five analyses of samples taken from three artefacts, *Towle 2002*, 315; *Towle – Henderson 2007*, 50 ff.). The glass of the Gorszewice bow was analyzed once before, a quarter of a century ago (*Frána – Maštalka 1990*, Tab. 2 and 3), but because of the imprecise determination of levels of potassium oxide among others (the K_2O content was marked as "<2.5%"), this analysis was not fully successful. Glass chemical composition analyses were carried out (but not published) for two leech-shaped fibula bows from the cemetery of Magdalenska Gora in Slovenia (*Towle – Henderson 2007*, 57).

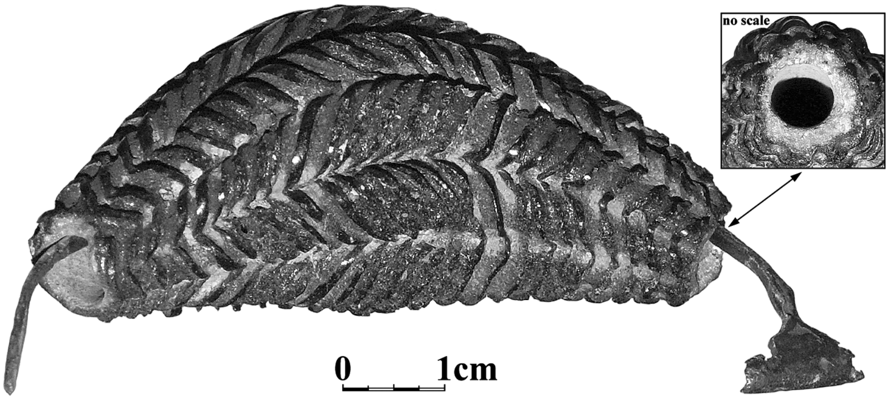


Fig. 1. Brooch slider from Gorszewice, Greater Poland.
Obr. 1. Návlek lučíku spony z Gorszewic, Velkopolsko.

Glasbügelfibeln representing the form discovered in Poland are generally well-known in terms of provenance (Italy, most likely the vicinity of Bologna) and chronology (end of 8th–7th century BC). An examination of the fibula bow from Gorszewice is of considerable significance for indicating the place of production and dating of other objects found in central Europe and made of a similar kind of glass. The aims of this paper are thus: (i) to characterize the glass chemical composition of the fibula bow from Gorszewice; (ii) to point out similarities and differences in the chemical composition of the inner and outer glass layers; (iii) to compare the results with the outcome of analyses of leech-shaped fibula bows discovered in Italy; (iv) to make a comparison with the results of analyses of artefacts (beads, heads of pins) made of glassy material dating from the Hallstatt C–D discovered in Poland.

2. Experimental

2.1. Samples

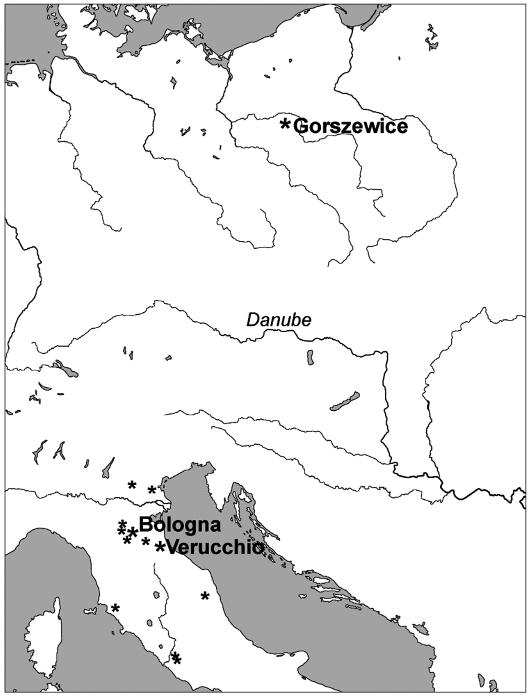
The matrix of the fibula bow from Gorszewice was comprised of two layers of glass: the inner (sample no. 23a/1), which was weakly translucent and yellowish, and the outer (sample no. 23a/2) not translucent, and dark blue, nearly black (black is the impression to the naked eye, while dark blue is visible under a microscope). The decoration was composed of 24 threads of opaque yellow glass applied to the matrix (at a right angle to the channel axis), subsequently scratched with a burin 12 times in alternating directions, to one side and then to the other (parallel to the channel), forming in effect a herringbone pattern in relief on the body (*Purowski 2012*, 82, 104, Fig. 30).

2.2. Analytical techniques

An ELAN 9000 (Perkin Elmer SCIEX, Canada) inductively coupled plasma mass spectrometer equipped with a laser ablation system LSX-213 (CETAC, USA) was used to obtain information about the elemental composition of the glass fibula bow. The laser ablation system combines a stable, environmentally sealed 213 nm UV laser (Nd-YAG, solid state) with a high sampling efficiency, variable 1 to 20 Hz pulse repetition rate and maximum energy up to 5 mJ/pulse. The experiment was performed using Ar as the carrier gas. The samples were placed inside the ablation cell with the Standard Reference Material NIST SRM 610 (http://www.nist.gov/). Three replicate single point ablations (ϕ=100 micrometers; 4.5 mJ of energy and repetition rate equal to 10 Hz) were carried out on each sample to register signal intensities for the selected isotopes with a 10 ms dwell time.

The fibula was too large to fit into the commercially available closed ablation cell, therefore a home-made open cell (*Wagner et al. 2011*) with an effective volume of 4.5 cm^3 was used within this work.

Fig. 2. Localization of sites (marked with an asterisk) with finds of brooch slider of types 1cA and 1dA according to *L. C. Koch's* (*2010*) classification.
Obr. 2. Poloha lokalit (označené hvězdičkou) s nálezy návleků lučíku spon typu 1cA a 1dA podle klasifikace *L. C. Koch* (*2010*).



It was important to seal the ablation cell while mounted to the fibula for the entire measurement period. The fibula is characterized by an uneven rough surface, which cannot be damaged during the investigations. To protect the sample-cell configuration from unfavourable possible air leaks between the sample and cell, the fibula was wrapped tightly with elastic PARAFILM (Pechiney Plastic Packaging), and the open cell was attached directly to its surface prior to the measurements.

During the measurements, 39 major, minor and trace elements were determined in the inner and outer glass of the fibula bow (*Tab. 1*), with three replicate single point ablations taken from the glass surface. The NIST SRM 610 calibration material was measured twice at the beginning and twice at the end of each run to correct the instrumental drift using the algorithm proposed by *Longerich et al.* (*1996*). Signal intensities were recorded for the following isotopes: ^{7}Li, ^{11}B, ^{23}Na, ^{26}Mg, ^{27}Al, ^{29}Si, ^{31}P, ^{39}K, ^{43}Ca, ^{45}Sc, ^{49}Ti, ^{51}V, ^{53}Cr, ^{55}Mn, ^{57}Fe, ^{59}Co, ^{61}Ni, ^{65}Cu, ^{66}Zn, ^{75}As, ^{85}Rb, ^{88}Sr, ^{89}Y, ^{90}Zr, ^{95}Mo, ^{109}Ag, ^{111}Cd, ^{118}Sn, ^{121}Sb, ^{133}Cs, ^{137}Ba, ^{139}La, ^{140}Ce, ^{178}Hf, ^{182}W, ^{208}Pb, ^{209}Bi, ^{232}Th and ^{238}U. Transient signals were saved and the background corrected and integrated using the LAMTRACE program created by *Jackson* (*2008*). The results were recalculated to the content of the oxides with NIST 610 as the external standard and ^{29}Si as the internal standard. Sum normalization to 100 wt% was applied based on the corresponding oxide concentrations.

The accuracy of the measurements was established by comparing the results for archaeological reference glass Corning B examined as an unknown sample to the values recommended for this glass in the literature (*Wagner et al. 2012*) and which are given in *Tab. 2*.

3. Results and Discussion

3.1. Types of glassy materials known from Poland

Glassy materials from the Early Iron Age in Poland can be subdivided into *glassy faience* and true *glass* (*Purowski et al. 2014*). The physical structure, meaning the quantitative proportions between

Site and sample no.	Colour of glass	SiO_2	Na_2O	K_2O	CaO	MgO	Al_2O_3	Fe_2O_3	MnO	Sb_2O_5	PbO	CoO	CuO	BaO	TiO_2	SnO_2	NiO	ZnO	As_2O_5	P_2O_5	B_2O_3
Gorszewice 23a/1	yellowish	70.91	14.51	1.888	1.831	0.970	5.805	1.807	0.234	0.001	0.020	0.001	0.082	0.044	0.373	0.003	<0.005	0.010	0.003	0.146	1.043
RSD		4.2	12.4	7.2	3.3	4.4	14.4	10.6	11.6	19.3	41.6	13.2	21.5	9.3	8.9	47.5		3.5	6.7	24.9	9.0
Gorszewice 23a/2	dark blue, nearly black	63.23	16.55	1.314	1.832	0.945	5.956	2.771	0.254	0.766	1.263	0.883	0.623	0.042	0.376	0.048	1.623	0.048	0.077	0.126	1.202
RSD		5.5	15.0	4.0	12.2	8.9	15.3	9.6	11.6	5.9	22.7	28.4	22.8	6.8	13.8	38.4	34.2	24.1	12.9	9.6	13.1

Site and sample no.	Colour of glass	Cs_2O	Sc_2O_3	V_2O_5	Rb_2O	SrO	Y_2O_3	ZrO_2	MoO_2	Ag_2O	La_2O_3	CdO	Ce_2O_3	HfO_2	Bi_2O_3	WO_3	ThO_2	UO_2	Li_2O	Cr_2O_3
Gorszewice 23a/1	yellowish	0.0002	0.0009	0.0065	0.0061	0.0140	0.0021	0.0191	0.0003	0.0003	0.0021	<0.0006	0.0038	0.0005	<0.0001	0.0001	0.0006	0.0003	0.0243	0.0046
RSD		16.3	6.0	13.8	21.0	9.0	11.0	14.6	12.7	6.9	8.6		11.9	13.2		22.0	5.7	9.6	10.9	17.1
Gorszewice 23a/2	dark blue, nearly black	0.0001	0.0009	0.0066	0.0041	0.0157	0.0020	0.0200	<0.0008	0.0009	0.0021	<0.0023	0.0039	0.0005	0.0003	0.0002	0.0006	0.0004	0.0151	0.0042
RSD		21.0	23.0	16.4	15.3	16.4	18.9	18.3		52.7	17.5		15.8	16.0	9.8	25.6	17.8	13.8	22.1	27.7

Table 1. Chemical composition of the glass of a brooch slider from Gorszewice (oxides wt%) obtained with LA-ICP-MS.
Tab. 1. Chemické složení skla návleku lučíku spony z Gorszewice (údaje v hm.%) získané metodou LA-ICP-MS.

glass and unreacted crystalline grains (most often quartz) or newly formed grains and crystals, is the classification criterion (cf. *Santropadre – Verità 2000*; *Angelini et al. 2004*). Based on potassium and magnesium oxides levels, the chemical composition of glassy faience can be divided into LMMK (low magnesium and medium potassium glass) and LMG_{GF} (low magnesium glass of glassy faience), whereas true glass is represented by HMG (high magnesium glass) and LMG (low magnesium glass; *Purowski 2012*; *2013*; *Purowski et al. 2012*; *2014*).

3.2. Chemical composition of the glass from Gorszewice

The inner glass (sample no. 23a/1) and the outer glass (sample no. 23a/2) of the Gorszewice leech-shaped fibula bow contain similar or identical amounts of Na_2O, K_2O, CaO, MgO and Al_2O_3 (*Tab. 1*). The K_2O content is average, MgO and CaO rather low, Al_2O_3 high; B_2O_3, TiO_2 and BaO relatively high. The similar properties of the glass among glassy materials from the Early Iron Age in Poland have been noted for LMMK glass[1] (*Figs. 3–5*). Similar quantities of the said compounds were also recorded for some glass leech-shaped fibula bows from Italy, especially samples 177, 178 and 373 (marked in *Figs. 3–4*) examined by A.C. Towle. However, the glass from Italy is distinguished by a higher CaO content (>2.7 %); the B_2O_3 content was not significant (*Towle 2002*, 315; *Towle – Henderson 2007*, Tab. 5).

The glass from Gorszewice was made of a two-component batch (sand and soda source). It cannot be ruled out that the glass from Italy with a higher CaO content received a third component, that is, a lime-bearing raw material (possibly sand with a higher content of calcium compounds).

The sand was also a source of other components besides silica, that is, compounds of aluminium, iron (the dark glass also contained another source of Fe_2O_3; see below), titanium, barium and boron, which usually occurred in a higher concentration in LMMK glass compared to HMG, LMG and LMG_{GF} glass (*Purowski et al. 2014*, 297). The high amount of aluminium compounds suggests the use of granitic sands, which are very rich in a feldspathic component (*Arletti et al. 2010*, 710). Relatively large amounts of barium compounds presumably entered the glass with the feldspathic component in sand (cf. *Silvestri 2008*, 1498; *Panighello et al. 2012*, 2950).

In the two glasses forming the fibula bow from Gorszewice, ZrO_2 is well correlated with Al_2O_3, TiO_2, B_2O_3 and SrO (*Fig. 6*). The strontium content in ancient glass is dependent on whether the sand used in production was inland or coastal. In the first case, with calcium carbonate derived from limestone, there is less SrO (<0.02%) and more ZrO_2 (>0.015%); in the second (if Mediterranean coastal sand is used) ZrO_2 (<0.01%) is typically low and SrO (>0.03%) high due to the aragonite in shells

[1] Most of the objects examined represent beads of various sizes (*Purowski et al. 2014*, Fig. 2). They are mostly blue in colour, either plain or decorated with a decoration of yellow glass forming a straight or wavy line, dots, circles or 'eyes'. Objects decorated in this way can be found in western and southern Poland in contexts dated to Hallstatt C – beginning of Hallstatt D (*Purowski 2012*). Two heads of bronze pins from the site at Domasław were also studied (*Purowski 2013*, Fig. 1m, 2o). They are blue in colour, decorated with straight threads and dots of yellow glass. Presumably, the examined objects made of glassy faience excavated from archaeological sites in Poland were produced in the 8^{th}–7^{th} century BC in the territory of Italy and the Slovenian–Croatian region.

Table 2. Major, minor and trace element oxide composition (wt%) of Corning B with RSD values (%) determined in this work compared with the values indicated by *Wagner et al.* (*2012*).
Tab. 2. Koncentrace oxidů hlavních, vedlejších a stopových prvků (v hm.%) z Corning B a hodnoty RSD (%) v této práci ve srovnání s hodnotami udávanými *Wagner et al.* (*2012*).

	Content	RSD	**Ref.**	RSD
Li_2O_3	**0.002**	25.4	**0.003**	4.6
B_2O_3	**0.036**	20.7	**0.036**	6.4
Na_2O	**16.3**	1.4	**16.5**	0.5
MgO	**0.911**	0.3	**0.789**	1.7
Al_2O_3	**4.03**	0.6	**4.63**	1.3
SiO_2	**63.23**	0.5	**62.02**	0.3
P_2O_5	**0.709**	1.4	**0.633**	1.2
K_2O	**1.07**	5.1	**1.30**	1.4
CaO	**8.77**	0.4	**8.75**	1.4
TiO_2	**0.106**	4.6	**0.099**	1.9
V_2O_5	**0.035**	1.7	**0.034**	1.2
Cr_2O_3	**0.008**	18.5	**0.010**	3.1
MnO	**0.229**	0.4	**0.241**	1.2
Fe_2O_3	**0.303**	3.0	**0.311**	1.5
NiO	**0.086**	11.9	**0.094**	1.1
CuO	**2.59**	0.6	**2.82**	1.7
ZnO	**0.304**	1.0	**0.211**	1.7
Rb_2O	**0.001**	3.7	**0.001**	2.3
SrO	**0.018**	1.9	**0.028**	2.3
ZrO_2	**0.025**	2.5	**0.023**	2.7
SnO_2	**0.027**	0.4	**0.024**	0.9
Sb_2O_5	**0.367**	0.2	**0.418**	1.8
BaO	**0.077**	1.6	**0.077**	2.5
PbO	**0.571**	2.1	**0.532**	2.5
Bi_2O_3	**0.005**	4.7	**0.004**	2.4

that are part of beach sand (e.g., *Freestone et al. 2003*; *Silvestri 2008*; *Panighello et al. 2012* and references therein). Relatively high ZrO_2 (0.019% and 0.02%) and low SrO (0.014% and 0.016%) in the Gorszewice glass indicates the use of inland sand in production. A similar situation was observed for most LMMK glass from Poland, whereas HMG from Hallstatt C from the Świbie site produced entirely different results (ongoing study).

Average amounts of K_2O and low MgO in the fibula bow glass make it difficult to indicate the kinds of soda (whether natron or plant ash) used as a fluxing agent in the glass batch. *Towle – Henderson* (*2007*, 57) determined the glass from Italy to be low magnesia (natron) soda-lime-silica glass. In our opinion, it is more likely that they were melted using plant ash (*Purowski et al. 2014*, 297).

3.3. Colourants of the glass from Gorszewice

The inner (yellowish) glass and the outer (dark blue going into black) glass of the Gorszewice fibula bow differ in their content of CoO, NiO, CuO, Fe_2O_3, PbO and Sb_2O_5 (*Fig. 7*), and to a lesser degree also SnO_2, ZnO and As_2O_5. Higher levels of these oxides occur in the black glass, showing that they were introduced into the glass with the colourant. The yellowish glass was not coloured intentionally, hence its colouring is due to the presence of iron compounds in the sand used for its production.

The presence of cobalt oxide in sample no. 23a/1 indicates the intent to give the glass a blue colour. Even a small amount of CoO (> 0.005%) turns the glass blue (*Bachtadze et al. 2002*, Tab. 3), whereas the glass from Gorszewice contains a seldom seen amount of 0.88% CoO (for examples of such high content, see *Purowski 2013*, 58; *Purowski et al. 2014*, Fig. 16). This excessive amount may have been the reason the glass is nearly black (*Santropadre – Verità 2000*, 39; *Towle 2002*, 108).

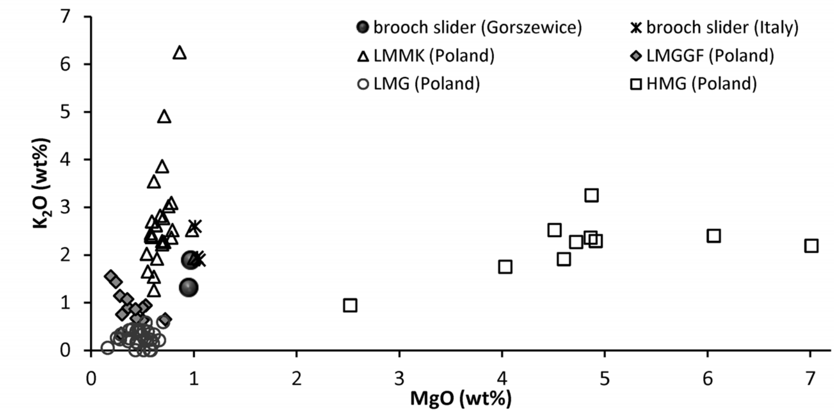


Fig. 3. MgO versus K_2O in the analyzed samples of glass from the brooch slider from Gorszewice (LA-ICP-MS) compared to that of brooch slider from Italy and from other Early Iron Age glasses from Poland. Italy after *Towle* (*2002*), LMMK and LMG_{GF} after *Purowski et al.* (*2014*), LMG after *Purowski et al.* (*2012*; *2014*), HMG after *Purowski et al.* (*2012*).
Obr. 3. Vztah mezi obsahy MgO a K_2O v analyzovaných vzorcích skla z návleku lučíku spony z Gorszewic (LA-ICP-MS) ve srovnání se sklem návleků lučíku spon z Itálie a dalšími vzorky skla časné doby železné z Polska. Itálie podle *Towle* (*2002*), LMMK a LMG_{GF} podle *Purowski et al.* (*2014*), LMG podle *Purowski et al.* (*2012*; *2014*), HMG podle *Purowski et al.* (*2012*).

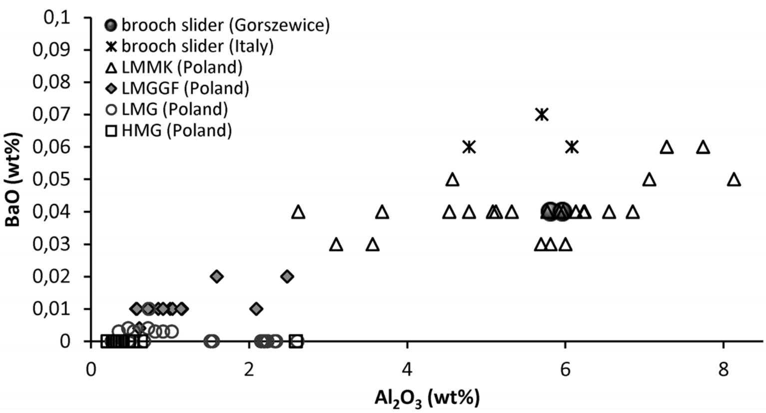


Fig. 4. Al_2O_3 versus BaO in the analyzed samples of glass from the brooch slider from Gorszewice (LA-ICP-MS) compared to that of brooch slider from Italy and from other Early Iron Age glasses from Poland. Italy after *Towle* (*2002*), LMMK and LMG_{GF} after *Purowski et al.* (*2014*), LMG after *Purowski et al.* (*2012*; *2014*), HMG after *Purowski et al.* (*2012*).
Obr. 4. Vztah mezi obsahy Al_2O_3 a BaO v analyzovaných vzorcích skla návleku lučíku spony z Gorszewic (LA-ICP-MS) ve srovnání se sklem návleků lučíku spon z Itálie a dalšími vzorky skla časné doby železné z Polska. Itálie podle *Towle* (*2002*), LMMK a LMG_{GF} podle *Purowski et al.* (*2014*), LMG podle *Purowski et al.* (*2012*; *2014*), HMG podle *Purowski et al.* (*2012*).

Alum, used commonly for colouring glasses during the New Kingdom in Egypt, was certainly not the colourant in the case of the Gorszewice fibula bow. In the Egyptian glass, the presence of cobalt is correlated strongly with higher levels of other elements, mainly oxides of aluminium, magnesium,

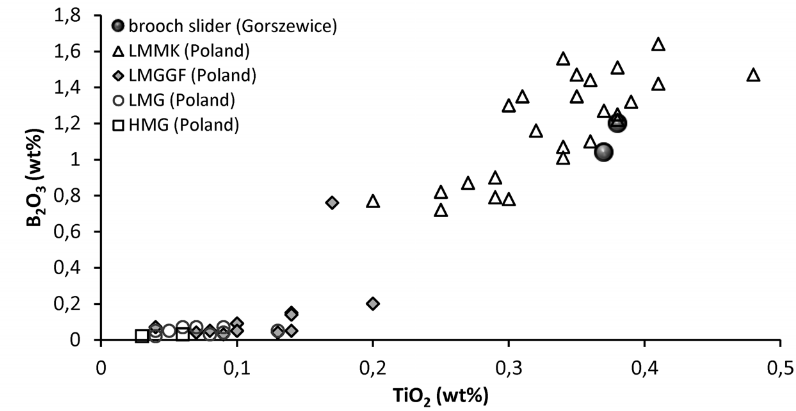


Fig. 5. TiO_2 versus B_2O_3 in the analyzed samples of glass from the brooch slider from Gorszewice (LA-ICP-MS) compared to other Early Iron Age glasses from Poland. LMMK, LMG_{GF} and LMG after *Purowski et al.* (*2014*), HMG after unpublished LA-ICP-MS analysis.
Obr. 5. Vztah mezi obsahy TiO_2 a B_2O_3 v analyzovaných vzorcích skla návleku lučíku spony z Gorszewic (LA-ICP-MS) ve srovnání s dalšími vzorky skla časné doby železné z Polska. LMMK a LMG_{GF} a LMG podle *Purowski et al.* (*2014*), HMG podle nepublikované LA-ICP-MS analýzy.

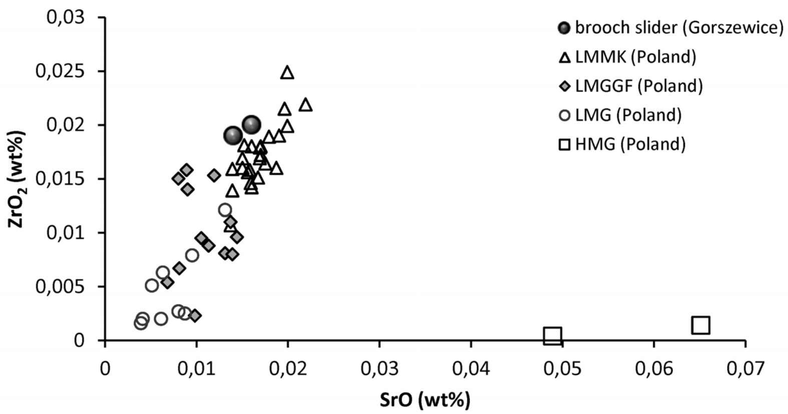


Fig. 6. SrO versus ZrO_2 in the analyzed samples of glass from the brooch slider from Gorszewice (LA-ICP-MS) compared to other Early Iron Age glasses from Poland. LMMK, LMG_{GF} and LMG after *Purowski et al.* (*2014*), HMG after unpublished LA-ICP-MS analysis.
Obr. 6. Vztah mezi obsahy SrO a ZrO_2 v analyzovaných vzorcích skla návleku lučíku spony z Gorszewic (LA-ICP-MS) ve srovnání s dalšími vzorky skla časné doby železné z Polska. LMMK a LMG_{GF} a LMG podle *Purowski et al.* (*2014*), HMG podle nepublikované LA-ICP-MS analýzy.

manganese, nickel and zinc (*Shortland – Tite 2000*, 145). Sample no. 23a/2 (coloured) demonstrates practically the same amounts of Al_2O_3, MgO and MnO as sample no. 23a/1 (not coloured).

In the glass of sample no. 23a/2, the higher content of cobalt oxide is correlated with a high level of nickel oxide (1.62%). Similar correlations were observed with regard to some glass from Europe dated to the Bronze Age or the Hallstatt period (e.g. *Frána – Maštalka 1990*, 62; *Purowski et al. 2014*, 302). Other contents of Co and Ni are encountered in most Egyptian and Mesopotamian glass (see, e.g., *Varberg et al. 2015*, Fig. 3). The glass from Gorszewice was presumably coloured with minerals

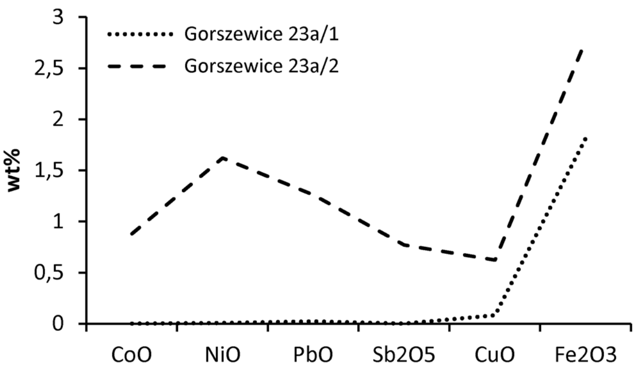


Fig. 7. Content of selected components of the glass of yellowish (sample 23a/1) and dark blue, nearly black colors (sample 23a/2) from Gorszewice.
Obr. 7. Obsah vybraných sloučenin skla žlutavé (vzorek 23a/1) a tmavě modré, skoro černé barvy (vzorek 23a/2) z Gorszewic.

commonly found in the territory of modern Germany, Austria, Switzerland, the Czech Republic and Slovakia (*Henderson 1985*, 280). The use of cobalt minerals may be responsible for introducing compounds of, among others, iron, nickel, arsenic, copper, sulphur, manganese, but also lead, antimony and zinc into the glass (*Santropadre – Verità 2000*, 39; *Koch 2011*, 25).

4. Conclusion

The processes applied to make the fibula bow from Gorszewice can be distinguished based on the elemental information collected during this work: (i) glassy faience was first produced using raw materials that introduced into glass of the LMMK-type high levels of silica, aluminium and iron compounds along with relatively high levels of titanium, barium and boron with the sand; while the fluxing agent was a source of an even higher content of sodium, medium potassium and insignificant magnesium compound; (ii) the body of the fibula bow was made of a larger uncoloured part of this mass, which was coloured only in part; (iii) the thick inner layer of glass was covered with the other thin layer of glassy material coloured with cobalt compounds, although this could not be distinguished visually in the finished leech-shaped fibula bow; (iv) finally, the decoration was cut into the surface of the outer glass.

As demonstrated by the research, the two layers of the fibula bow were made concurrently in the same workshop, not in different areas using different raw materials for the inner and outer layers. The double layer of the fibula bow indicates a sparing approach to the colourant, which was added frugally to small parts of the glassy material. However, the colouring process was apparently beyond the control of the artisans, because excess use of cobalt compounds discoloured the glass to a very dark blue, nearly black shade.

The examination of the fibula bow made of two layers of glassy faience (coloured and uncoloured) produced a list of compounds introduced into the glass with the colourant (including CoO, NiO, CuO, Fe_2O_3, PbO, Sb_2O_5, SnO_2, ZnO and As_2O_5). Such a determination cannot usually be performed for monochrome beads.

The Gorszewice fibula was made at the end of the 8th or in the 7th century BC, probably in Italy. *Per analogiam*, other glassy faience artefacts from Poland (especially those featuring a chemical composition resembling that of the fibula bow from Gorszewice) may also be taken as being manufactured in Italy (or the immediately neighbouring regions of modern-day Slovenia and Croatia).

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Návlek lučíku spony italské provenience z doby halštatské v Polsku

Článek představuje výsledky laboratorní analýzy skla skleněného návleku lučíku spony objeveného v hrobě datovaném do období Ha C (ca 750/700–600 BC) v Gorszewicích, ca 25 km severozápadně od Poznaně (Velkopolsko). Zkoumána byla jak vnitřní vrstva nažloutlé barvy, tak povrchová vrstva, na pohled tmavě modrá až černá. Hlavním cílem studia bylo: (i) určit chemické složení skla návleku lučíku spony z Gorzsewice; (ii) zjistit rozdíly v chemickém složení vnitřní a vnější skelné vrstvy; (iii) srovnat výsledky se závěry zkoumání skla návleků lučíku spon objevených v Itálii; (iv) komparativní studie skelného materiálu v předmětech z období Ha C-D objevených v Polsku.

Stejně jako LMMK sklo (vyznačující se nízkou koncentrací hořčíku a střední koncentrací draslíku) skelné fajánse, běžné v období Ha C, i sklo návleku lučíku spony z Gorszewic charakterizuje střední koncentrace K_2O, vysoká koncentrace Al_2O_3 a Fe_2O_3, a poměrně vysoká úroveň B_2O_3, TiO_2 a BaO. Vnitřní i vnější skelná vrstva návleku lučíku spony z Gorszewic mají téměř stejný nebo totožný obsah následujících složek: Na_2O, K_2O, CaO, MgO and Al_2O_3, ale liší se mj. koncentracemi CoO, NiO, CuO, Fe_2O_3, PbO a Sb_2O_5. Vyšší koncentrace některých oxidů se projevují v tmavším skle, což je způsobeno příměsí barvících složek. Nažloutlé sklo nebylo obarveno záměrně: jeho barva je způsobena přítomností sloučenin železa v písku.

Spona byla vyrobena v Itálii, nejspíše v regionu Boloně, zřejmě na sklonku 8. nebo v 7. století BC. Chemické složení skla návleku lučíku spony z Gorszewic vykazuje značnou podobnost se sklem několika návleků lučíku spon z Itálie z 8.–7. století BC a sklem korálků a hlavic jehel známých v kontextech datovaných do období Ha C v Polsku. Předměty z LMMK skla známé ve střední Evropě byly s největší pravděpodobností vyrobeny v Itálii a/nebo v oblasti dnešního Slovinska a Chorvatska.

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